UNCLASSIFIED

63-2-6

NEW YORK NAVAL SHIPYARD
NAVAL BASE, BROOKLYN 1, NEW YORK

9370:JZL:nr
Lab. Project 4759-14
Progress Report 11

27 MAR 1963

From: Commander, New York Naval Shipyard
To: Distribution List

Subj: Application of cavitation-erosion resistant neoprene coating ML-C570 to struts, foils, rudders and flaps of hydrofoil patrol craft, PC(H)-1 . Subproject SF013 13 01, Task 906, Bureau of Ships Identification No. 14-906-1

Ref: (a) BUSHIPS ltr F013 13 01, Ser 634C1-642 of 10 Jul 1961, BUSHIPS Identification No. 14-906-1: SF013 13 01, Task 906
(b) BUSHIPS ltr F013 13 01, Ser 634C1-402 of 7 May 1962, Subproject SF013 13 01, Task 906, BUSHIPS Identification No. 14-906-1
(c) CAPT J. J. Stilwell, LTCDR P. W. Nelson, LTCDR W. R. Porter, USN Hydrofoils at the Crossroads, Aerospace Engineering Mar 1961 10, 11, 68-78, IAS Paper No. 61-44
(d) I. Palmer and J. K. Roper, "Fundamental Characteristics of Hydrofoil Craft," SAE Preprint S273, 23 Feb 1961
(e) COMNAVSHIPYDNYK ltr 949:JZL:ep, Lab. Project 4759-14, Progress Report 10 of 15 Feb 1962
(f) BUSHIPS ltr PC(H)-1, Ser 526-438 of 19 Mar 1962
(g) U. R. Evans "The Corrosion and Oxidation of Metals: Scientific Principles and Practical Applications", London, Edward Arnold Ltd, 1960
(h) COMNAVSHIPYDNYK ltr 949:JZL:nt, Lab. Project 4759-14 of 20 Apr 1962 to SUPSHIPS, Seattle
(i) Federal Test Method Standard 601, 12 Apr 1955, Rubber: Sampling and Testing
(j) COMNAVSHIPYDNYK MATLAB ltr 949:JZL:nr, Lab. Project 4759-14, Id. No. 31-906-2, Progress Report 7 of 18 Apr 1961
(k) J. Z. Lichtman, D. H. Kallas, C. K. Chatten and E. P. Cochran, Jr. "Cavitation Erosion of Structural Materials and Coatings," Corrosion Vol. 17, No. 10, Oct 1961, 119-127

Encl: (1) Attendees at Conference on Cavitation-Erosion Resistant Coatings for Propeller of USNS AMERICAN EXPLORER (T-AO 165) at BUSHIPS 20 Nov 1961
(2) Description of Application of Coating Materials to Structural Sections of PC(H)-1
(3) Photo L18196-455, Figure 1 PC(H)-1 Forward and Aft Foil and Strut Sections
(4) Photo L18196-456, Figure 2, Preparation and Coating of Forward Rudders, Strut and Flaps

Encl: (5) Photo L18196-457, Figure 3, Forward Foil and Flap and Aft Foil, Flap and Nacelle Sections
(6) Photo L18196-538, Figure 4, Cavitation Erosion Damage of Neoprene ML-C570 Coating, AISI 1016 Steel and HY80 Steel
(7) Table 1 - Mechanical Properties of ML-C570 Coating
(8) Coating Repair Procedures

1. INTRODUCTION

A cavitation-erosion resistant ambient-curing, solvent type neoprene coating, Formulation ML-C570, developed by the Material Laboratory under authorization of references (a) and (b) has been applied to the foils, struts, flaps and rudders of the PC(H)-1, at the J. M. Martinac Company, Tacoma, Washington. The application was started 11 June 1962 and completed in August 1962. This report will describe and discuss the application procedures and their suitability under shipyard conditions, materials employed, and characteristics of the coating as determined in the Material Laboratory.

2. BACKGROUND

The erosion resistance and other characteristics of the ML-C570 coating material as determined in the Material Laboratory were described at a meeting in Code 634C of the Bureau on 20 November 1961. Attendees at this meeting are listed in enclosure (1). This meeting had been convened to discuss cavitation erosion of a 22 ft diameter manganese nickel bronze propeller of the USNS AMERICAN EXPLORER (T-AO-165), and means of controlling this damage.

3. It had been indicated in references (c) and (d) that under non-supercavitating conditions of operation, the foils and struts of hydrofoil craft would be required to have a high degree of corrosion and cavitation erosion resistance. In view of the low cavitation erosion resistance of epoxy coatings as reported in reference (e) and on the basis of the high erosion resistance of the ML-C570 coating, reported as described above, a change order was issued under reference (f), substituting the application of the ML-C570 neoprene coating for the previously specified HYCON-75 epoxy coating, on the foils, struts, rudders and flaps of the PC(H)-1.

4. DESCRIPTION

The application of the ML-C570 coating and related primers, adhesives and smoothers, to the structures of the PC(H)-1 is described in detail in enclosure (2), including:

a. Structures coated (also illustrated in enclosures (3), (4), (5)).

b. Surface preparation.

c. Facilities for application of coating.

d. Coating materials.

e. Coating application procedures.

Personnel of the J. M. Martinac Company, The Boeing Company and SUPSHIPS, USN, Seattle, were instructed in the surface preparation of the structural parts, the use of the coating materials and their application to the foil and strut sections of the PC(H)-1 by Material Laboratory engineer, J. Z. Lichtman, during his assignment to the Martinac Company from 11 to 22 June 1962. The spray application of the catalyzed ML-C570 coating was tested at the Martinac Company, using a Graco airless spray gun, Model 205-162, Series 6A1, with a 163-821 tip. A uniform coating was not obtained. Therefore the brush-application procedure, described in enclosure (2), was used in the present application.

5. TESTS FOR COATING PROPERTIES

Test specimens prepared simultaneously and in an identical manner to the preparation and coating of the forward strut, rudders and flaps, were forwarded to the Material Laboratory for test. These tests included:

a. Cavitation erosion resistance.

b. Mechanical properties of supported and unsupported films in:

(1) Initial condition, and

(2) After fresh water immersion.

Test specimens prepared in the Material Laboratory were also subjected to the above tests, including, in addition, evaluation of mechanical properties after exposure to 4% simulated sea water for periods up to 28 days.

c. Cavitation erosion exposure: The 12 in. dia. x 1/8 in. thick cavitation test disks were run in the rotating disk apparatus at 3200 rpm and 15 psig, as described in references (j) and (k), using fresh water or sea water, as shown in enclosure (6). Erosion measurements of the metallic specimens were made after the exposure periods, using a microsyringe, Hamilton Company No. 701-N (10 µl capacity, 0.2 µl graduations) or No. 705-N (50 µl capacity, 1 µl graduations). The liquid used in the erosion volume measurements was a silicone oil of 50 cs viscosity.

d. Mechanical properties determined included:

(1) Tensile strength: reference (i), Method 4111.

(2) Ultimate elongation: reference (i), Method 4121.

(3) Tear strength: reference (i), Method 4221.

(4) Tensile hysteresis: reference (j), paragraph 5.c.

(5) Volume swell: reference (1), Method 6221.

(6) Adhesive Strength: reference (i), Method 8031.

(7) Tensile modulus: reference (i), Method 4131.

Results of cavitation erosion exposure on the ML-C570 coating material applied under field and laboratory conditions, and of ferrous structural materials exposed under the same conditions are shown in enclosure (6). Results of evaluation of the mechanical properties of the ML-C570 coating material are summarized in enclosure (7).

6. CONCLUSIONS

The following conclusions are indicated by the results of the described application and tests of the coating materials:

a. Brush application of the solvent-type ambient curing neoprene coating ML-C570 to large, irregularly-shaped structures as represented by the foils, struts, rudders and flaps of the PC(H)-1 is feasible and practical. Application procedures as described in enclosure (2) were used by shipyard personnel without difficulty.

b. The values of properties of the coating material as applied in the field are comparable and, in some instances, superior to those obtained on laboratory-applied samples, as shown in enclosure (7). The initial tear and adhesion properties of the Tacoma samples were somewhat higher than the Laboratory-prepared samples, while the tensile strength and ultimate elongation properties of the Laboratory-prepared samples were higher than those of the Tacoma samples.

c. Although spray application of the ML-C570 coating was attempted as described in paragraph 4, this formulation is applicable by brush only, in accordance with procedures described in enclosure (2), section e.

d. Long time immersion of the coating in fresh and sea water resulted generally in slight decreases in tensile strength, ultimate elongation, tear strength and adhesive strength of the coating. Evidence of blistering after long-time immersion of the Tacoma samples indicates the need for more thorough cleaning and priming of the substrate to prevent localized adhesion separation because of internal stresses. As indicated by Evans, reference (g), the tendency to blister may be stronger in distilled water than in sea water. This factor, as well as the more uniform cleaning of the adhesion test specimens in the Laboratory application, may account for the lack of blistering of the specimens exposed in sea water despite their lower adhesive strength.

7. REPAIR PROCEDURES

Areas of the ML-C570 coating which may be damaged after application, and during or after installation of coated structures in the boat, may be repaired as described in enclosure (8) and reference (h).

8. RECOMMENDATIONS AND FUTURE WORK

Investigation of the ML-C570 coating material to determine its antifouling properties is presently underway. Also, other elastomeric coating systems designed for superior erosion and fouling resistance are being developed. Therefore, recommendations for further service applications of the ML-C570 coating will be held in abeyance at the present time, pending results of present service applications and the above development work.

J M McGreevy
J.M. McGREEVY
By direction

Attendees at Conference on Cavitation-Erosion Resistant Coatings for Propeller of USNS AMERICAN EXPLORER (T-AO 165) at BUSHIPS, 20 November 1961

S. A. Fielding	Maritime Administration, Code 810
W. M. Jackson	MSTS, Code M4R12
N. W. Springer	MSTS, Code M4R61
CDR E. P. Cochran, Jr., USN	ONR, Code 429
B. L. Silverstein	ONR, Code 438
S. W. Doroff	ONR, Code 438
E. A. Bukzin	BUSHIPS, Code 342A
D. Pratt	BUSHIPS, Code 634C1
G. Sorkin	BUSHIPS, Code 341A
I. Fioriti	BUSHIPS, Code 442
R. C. Beatty	BUSHIPS, Code 644
D. H. Kallas	Material Laboratory, Code 9300
J. Z. Lichtman	Material Laboratory, Code 9370

DESCRIPTION OF APPLICATION OF COATING MATERIALS
TO STRUCTURAL SECTIONS OF PC(H)-1

a. Structures of PC(H)-1 Coated with Neoprene Formulation ML-C570

The structures of the PC(H)-1 coated during the period 11 June to 22 June 1962 included the following:

(1) Forward Strut, Figures 1A, B, D, 2H, J, K

(2) Forward Flaps, Figures 1B, 1D, 2L, 3P

(3) Forward rudders (upper and lower) Figures 1A, B, D, 2I, L

These sections had previously been subjected to load deflection tests, the fixtures for which are shown attached to the foil in Figures 1A, B

Other Sections coated from 22 June to August 1962 included:

(1) Forward foil, Figures 1A, B, D, E, 3P

(2) Aft struts, Figures 1C, F

(3) Aft flaps, Figure 3M

(4) Aft foils, Figures 3M, N, O

b. Surface Preparation

All metallic surfaces to be coated were disk ground to remove the previously applied 117 pretreatment primer and 84 anti-corrosive coatings. The disks used in grinding were Type BFH, MOS 6000 RPM, 9 x 1/8 x 7/8, A 24-5-BFH, supplied by the Pacific Grinding Wheel Company, Everett, Washington. The roughness of the metal surfaces after grinding was approximately 150-180 μ in.

c. Facilities used in Application of Cavitation-Erosion Resistant Coating to PC(H)-1

After surface grinding to remove all the previously applied 117 pretreatment and 84 anti-corrosive coatings, the parts were moved into a shed shown in Figure 2G. This shed, approximately 40 ft long by 15 ft wide by 10 ft high was equipped with a removable roof to permit placing into the shed the larger foil and strut sections, which would not clear the doors and would require handling by crane. The shed had a fan blowing inward through a filter to provide positive pressure in the building and prevent dust sifting inward. Steam coils were located along the long walls near the floor to provide heat when the room temperature dropped below 60F. To supplement the natural light entering through the plastic roof panels, drop lights were provided for illumination of the under sides of structures during coating. A temperature range of 60 to 88F and relative humidity range of 36 to 72% was obtained in the shed during the period of 11 June to 22 June 1962.

d. Coating Materials

The coating materials included the following:

(1) Metal degreasing agent. Trichloroethylene (TCE)

(2) Pretreatment primer, Formula 117, Specification MIL-C-15328A

(3) Adhesive, Bostik 1007, B. B. Chemical Div., United Shoe Machinery Company, Cambridge 39, Massachusetts.

(4) Neoprene Coating, Material Laboratory Formulation ML-C570. Formulation developed by Naval Material Laboratory, manufactured by Rubber and Asbestos Corporation, 225 Belleville Avenue, Bloomfield, New Jersey because of quantity required (176 gals).

Formulation:

Base:	Neoprene AD 20	100 part by wt
	Hi Sil 233	20 part by wt
	Bentone 27	1 part by wt

Processing: Band the Neoprene AD 20. Mix Bentone 27 into 1/3 of Hi Sil 233. Incorporate this mix into neoprene, followed by addition of remaining Hi Sil 233. Mill to obtain smooth compound. Refine and sheet off. Dissolve in toluene/amyl acetate (1:1 by wt) to a 20% solution by weight. Viscosity of base solution shall be in range of 1000 to 5000 cps as determined with Brookfield Model RV viscometer at 20 rpm, with a No. 4 spindle at 77F in a 1 pt can.

Catalyst: Catechol solution in toluene 1% by weight. Packaged in units of 0.37 gal catalyst (in 1 gal can) per 4 gals of base (in 5 gal can).

(5) Epoxy smoother primer. Coast Pro-Seal Formula 820 (2 part). Coast Pro-Seal and Mfg Co., 2235 Beverly Road, Los Angeles 57, California.

(6) Epoxy smoother. Coast Pro-Seal Formula 813 (2 part).

(7) Epoxy-neoprene adhesive. Consisting of Raybestos-Manhattan formula Raybond 86009 (2 part) epoxy and ML-C570 (plus catalyst) in a 1:1 ratio by weight. Raybestos-Manhattan, Inc., Raybestos Division, Bridgeport 2, Conn.

(8) Toluene (technical grade). For use in tackifying neoprene coating and in washing brushes.

(9) Methyl ethyl ketone (MEK) (technical grade). May be used in thinning Bostik 1007. Approximately 5% of MEK may be used to increase coverage of Bostik 1007 and to obtain more uniform adhesive coating. The cost and coverage estimates of the neoprene coating material and adhesives furnished by the Material Laboratory are given in Table 2.

TABLE 2

MATERIAL COSTS AND COVERAGE ESTIMATES

Material	Amt req'd	Cost/gal	Coverage sq ft/gal
Neoprene coating material ML-C570			
Base	160 gal	5.60	9 at 30 mil ga
Catalyst (0.37 gal/unit)	40 units	3.30/unit	dry film
Bostik 1007	6 gal	7.00	200
Raybond R86009 base	1 gal	25.70	300
activator	1 gal	10.50	

e. Coating Application Procedures

(1) Application of neoprene 570 to base HY 80 steel and Type 316 stainless steel weldment inlays.

(a) Degrease metal thoroughly with TCE, using clean cloths or stiff bristle brush, and allow a 20 minute dry time.

(b) Apply 1 brush coat Formula 117 primer, and allow a 40 minute dry time.

(c) Apply 1 brush coat of Bostik 1007 adhesive and allow a 60 minute dry time.

(d) Apply neoprene coating ML-6570 (2 part) by brush.

1 gal can of catalyst (0.37 gal) to a 5 gal can (containing 4 gal) of base. (100 cc catalyst per kg base). 1 hr degassing time after mixing. Pot life 16 hrs.

Dry time per coat 45-60 min to obtain tack-free condition prior to application of next coat. After drying for several hours (e.g. overnight) last coat is tackified by brushing lightly with toluene before applying additional coats of ML-C570. Prior to tackifying, thickness of applied coating is to be determined with Elcometer or equivalent thickness gauge. Final thickness to be 30 to 40 mils (attained by approximately 25 coats). The coating is then allowed to cure at least 7 days at higher than 60F.

(2) Application of Coast Proseal epoxy smoother formula 813 to depressions in foils (See Figure 2L) and recesses in struts, foils and rudders.

(a) Degrease metal with TCE, using clean cloths or stiff brush and allow a 20 min dry time

(b) Apply 1 brush coat Formula 117, and allow a 40 min dry time.

(c) Brush apply 1 coat Coast Proseal epoxy Formula 820 (Equal parts by volume of parts A and B), and allow a 12 hour cure time.

(d) Apply Coast Proseal Formula 813 (Equal parts by volume of parts A and B). Smooth out to faired surface. Cure 12 hours.

(e) Finish grind to faired surface.

(3) Application of Neoprene 570 to epoxy smoother.

(a) Wash epoxy smoother with toluene, using clean cloth.

(b) Make up epoxy-neoprene adhesive described in enclosure (2) d 7. Raybond 86009 adhesive to consist of 3 parts base to 2 parts activator by weight and to be added to catalyzed ML-C570 in 1:1 ratio by weight. Typical formula to consist of:

Raybond 86C09 base (3 pts by wt):		15 gms
	activator (20 pts by wt):	10 gms
Neoprene 570 base + catalyst		25 gms

(c) Brush 1 coat of epoxy-neoprene adhesive onto cleaned smoother.

(d) Allow to dry approximately 2 hours until tacky.

(e) Apply catalyzed neoprene ML-C570 as in (1)(d) above.

(4) Application of neoprene 570 to pressure-sensitive aluminum foil covering (adhesive type PS-18) used in water-proofing of external strain gages on aft struts and hydrofoil.

(a) Degrease HY80 with TCE, using clean cloths or brush.

(b) Degrease aluminum foil surface with TCE.

(c) Cut aluminum foil with scissors to desired form. Remove masking tape from adhesive. Apply foil to metal and roll down with smooth-faced steel roller (Hoggson and Pettis Co. 1-1/2 in. x 1-1/2 in. or equal).

(d) Apply 1 brush coat 117 primer to aluminum and adjacent HY80 steel, and allow a 40 min dry time.

(e) Apply Bostik 1007 and Neoprene ML-C570 as in (1)(c) and (d) above.

(5) Forward Strut

(a) Strut was mounted in jig as shown in Figure 2 H, after surface preparation, enclosure (2) b.

(b) All joint and bearing areas were masked.

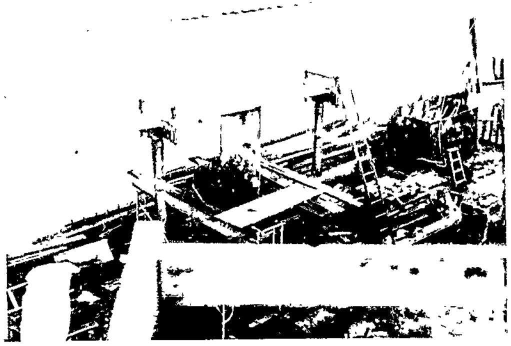
(c) Coating applied as described in (1) through (3) above to within 2 inches of lower flange and to bolt cavity of upper flange, Figure 1. D, 2 H and K.

(d) Coating in upper rudder recess areas adjacent to rudder surface, Figure 2K, applied to thickness of 15 mils for clearance in rudder operation.

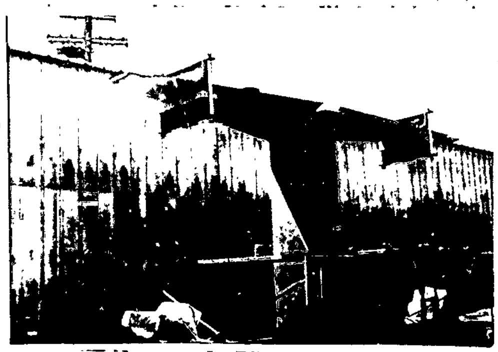
(6) Rudders and Flaps

(a) Lower rudder positioned as shown in Figure 2I, upper rudder hung as shown in Figure 2L. Micarta bearing shims bonded to HY80 with Coast Proseal Formula 813 epoxy.

(b) Flaps positioned on wood horses as shown in Figure 2L. All joints, bearing areas and holes for Locktite installation masked. Depressions in flap surfaces smoothed as described in (2) above. Neoprene ML-C570 applied to thickness of 15 mils at leading edge areas and hinge areas, Figure 1E and 2L. Otherwise, thickness of coating was 30 to 40 mils as indicated in (1) above.



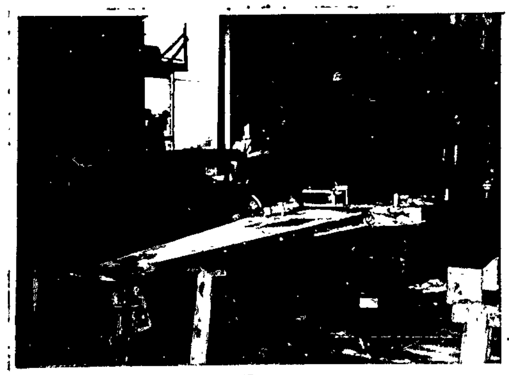
A. Forward Foil and Strut Assembly. Inverted. Jigs Attached for Load Deflection Tests.



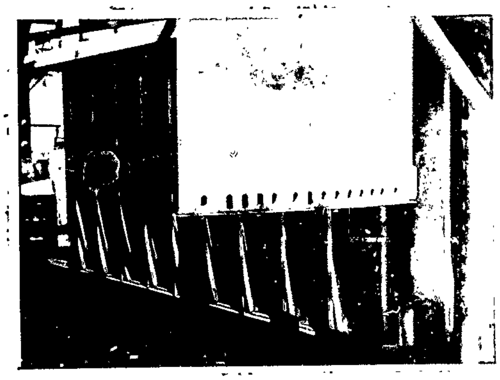
B. Forward Foil and Strut Assemblies.

C. Aft Struts.

D. Forward Foil and Strut Showing Attachment Bolts.



E. Forward Foil. Flap Removed.



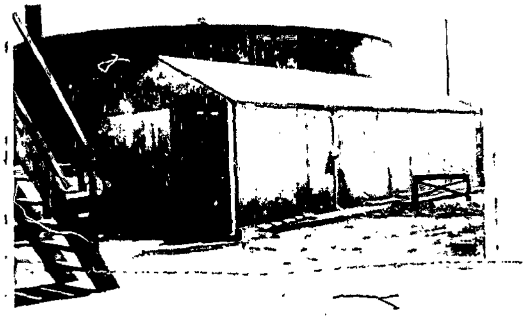
F. Aft Strut Showing Attachment Bolt Recesses to Nacelle Section.

MATERIAL LABORATORY

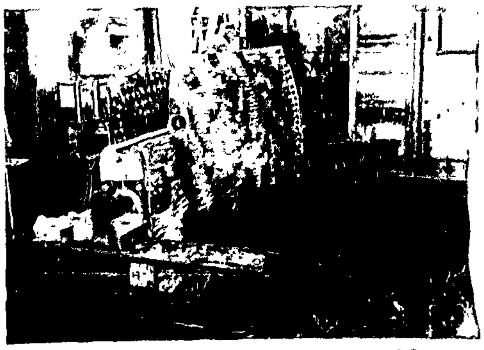
LAB. PROJECT 4759-14

Enclosure (3) - Figure 1, PC(H)-1, Forward and Aft Foil and Strut Sections

PHOTO L18196-455

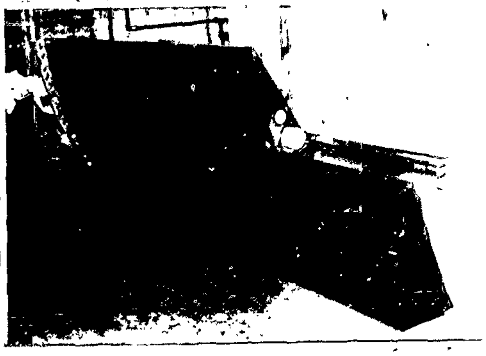


G. Heated Shed in Which Neoprene Coating Work was Conducted.



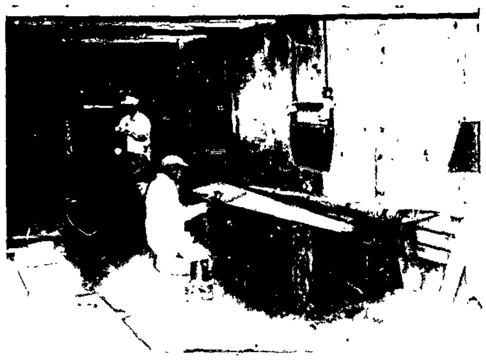
J. Forward Strut After Disk Grinding.

H. Application of Bostik 1007 to Forward Strut.



K. Forward Strut Coated With ML-C570 Neoprene.

I. Forward Lower Rudder Coated With ML-C570 Neoprene.

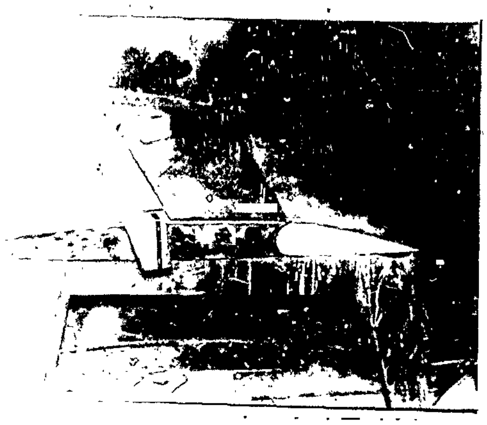


L. Application of Smoother 813 to Fwd Flaps. Fwd Upper Rudder Coated with ML-C570 Neoprene.

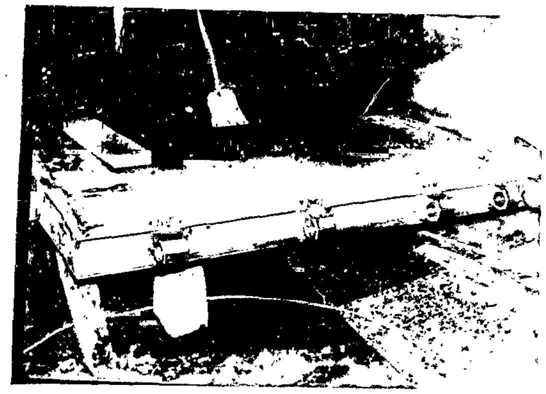
MATERIAL LABORATORY LAB. PROJECT 4759-14

Enclosure (4) - Figure 2, Preparation and Coating of Forward Rudders, Strut and Flaps

PHOTO L18196-456



M. Aft Port Foil and Flap. Prior to
Disk Grinding.



N. Aft Port Foil, Showing Hinge Blocks
and Hinge Recess. Flap Removed.

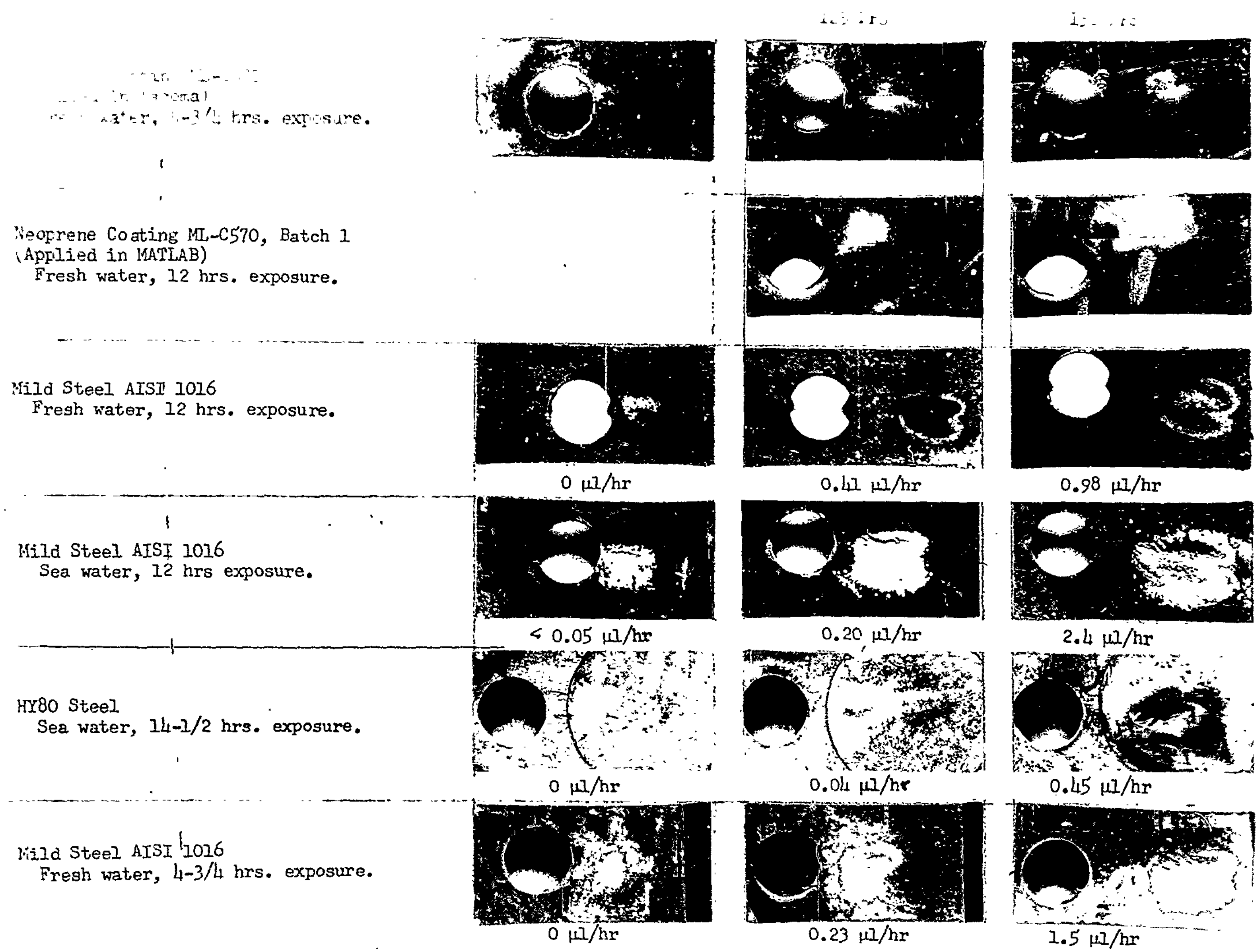
Aft Stbd Foil and Nacelle Under
Construction.

P. Forward Foil and Flaps, Assembled.
Coated with Neoprene ML-C570. Hinge
Block Pins to be Coated.

MATERIAL LABORATORY LAB. PROJECT 4759-14

Enclosure (5) - Figure 3, Forward Foil and Flap, and Aft
Foil, Flap and Nacelle Sections

PHOTO L18196-457



MATERIAL LABORATORY LAB. PROJECT 4759-14

Enclosure (6) - Figure 4, Cavitation Erosion Damage of Neoprene ML-C570 Coating, AISI 1016 Steel and HY80 Steel

PHOTO L18196-538

TABLE 1

MECHANICAL PROPERTIES OF ML-C570 COATING

Property	Condition								
		After immersion in fresh water at 74F				After immersion in sea water at 74F			
	Initial	3 days	7 days	14 days	28 days	7 days	14 days	21 days	28 days
Tensile strength, psi	2400 (2)		2085						
	2540 (3)					2785	2250	2665	
	2905 (4)		2595	2495	2570	3015	2840	2345	
Ultimate elongation, %	510 (2)		700						
	805 (3)					1000	1085	985	
	1075 (4)		1070	1385	1035	865	905	780	
Tear strength, ppi	173 (2)		140						
	140 (3)					152	135	128	
	163 (4)		149	121	151	146	197	180	
Tensile hysteresis, %	66		66	81	76				
Volume swell, %		5.35							
Adhesive strength, ppi, HY80 (2)	31		28	24	25 (1)				
316 Stainless Steel (2)	34		28	24	24 (1)				
AISI 1016 (4), (6)	12		13	12	15 (5)	14	13		18 (5)
Tensile modulus (100% elong), psi (3)	890					785	715	740	
(4)	915					880	785	655	
(4)	590		650	575	610				
(200% elong), psi (3)	1060					885	815	855	
(4)	950					910	855	755	

TABLE 1

Notes: (1) Random blistering of coating at specimen margin.

(2) Tacoma samples.

(3) Applied in MATLAB, Lot 1, Contract 131-2-60401DDX, 20 Mar 1962, 88 gals.

(4) Applied in MATLAB, Lot 2, Contract 131-60431DDX, 25 Apr 1962, 88 gals.

(5) No indication of blistering. Separation 100% in Bostik 1007.

(6) No. 50 grit disk ground.

COATING REPAIR PROCEDURES

Areas of the ML-C570 neoprene coating which have been damaged during or after assembly of the coated sections or operation of the boat shall be repaired in the following manner. The original coating shall be faired at the damaged margins using a sharp knife or 80 grit sand paper. The faired coating surface shall be tackified using a light brush coat of toluene. The catalyzed ML-C570 shall then be applied, fairing in the patch as it is applied. If the original coating has been damaged to the base metal and adhesion failure has occurred, the coating shall be cut away to the extent of adhesion separation and faired at the residual margin. The metal shall be cleaned using abrasive cloth (50 mesh) to white metal, washed with TCE and reprimed with 117 primer and Bostik 1007 adhesive prior to recoating with ML-C570. The new coating materi- shall be faired carefully into the original coating margin to prevent a non-smooth surface margin. Should this occur, the roughness shall be smoothed with 80 grit sand paper and brushed lightly with toluene.

DISTRIBUTION LIST

	No. of Copies
BUSHIPS (210L)	3
BUSHIPS (634C)	3
BUSHIPS (649P, 342A, 320, 340, 420, 442, 633P, 634B, 644, 341A, 341B)	1 each
Office of Naval Research (ONR) (Code 438) & (Code 429)	1 each
BUDOCKS (Code D 420, Room 2B73	1
NAVSHIPYDS Boston (Code 276) Mare Island (Rubber Lab.) & (Paint Lab., Code 303P) Puget Sound (Bremerton) (Material Lab.) Norfolk (Paint Lab.)	1 each
David Taylor Model Basin (Code 526) & (Code 589)	1 each
Engineering Experiment Station (Metals Lab.)	1
Underwater Sound Laboratory	1
USN Civil Engineering Lab. Pt. Hueneme, Calif.	1
Astronautical Systems Div. Wright-Patterson AFB, Ohio	1
Maritime Administration Washington 25, D.C.	1
Lewis Research Center (Library) NASA, Cleveland 35, Ohio	1
Bureau of Reclamation, Dept. of the Interior Bldg. 53, Denver Federal Center Denver 2, Colorado	1
National Research Council Prevention of Deterioration Center Washington, D. C.	1
Armed Services Technical Information Agency (ASTIA) Arlington 12, Va.	10

DISTRIBUTION LIST (Cont'd)

(1 to each unless otherwise noted)

Prof. A. G. Anderson
St. Anthony's Falls Hydraulics Lab.
University of Minnesota
Minneapolis, Minn.

Prof. F. R. Eirich (MATLAB Consultant)
c/o Polytechnic Inst. of Brooklyn
333 Jay St.
Brooklyn 1, N. Y.

California Inst. of Technology
Pasadena, California
Attn: Prof. A. T. Ellis,
Hydrodynamics Lab.

Boeing Airplane Company
Aero-Space Division
Seattle 24, Washington
Attn: Mr. G. E. Hughes, Section Chief
Materials and Processes

Chance-Vought Aeronautics Corp.
P. O. Box 5907, Dallas, Texas
Attn: Mr. A. Hohman (Unit 53430)

Electric Boat Division
(VIA SUPSHIP Groton)
General Dynamics Corp.
Attn: Mr. J. J. Reihl

Grumman Aircraft Engineering Corp.
Bethpage, L.I. New York
Attn: Mr. R. Heitzman

Hydronautics Inc.
Pindell School Road
Laurel, Md.

International Nickel Co. Inc.
P. O. Box 262
Wrightsville Beach, N. C.
Attn: Dr. T. May

Lockheed Aircraft Corp.
Missiles & Space Div.
Palo Alto, California

Lockheed Aircraft Corp.
Hydrodynamics Research
Burbank, California
Attn: Mr. Kenneth E. Hodge

Lockheed Aircraft Corp.
Missiles & Space Div.
3251 Hanover St.
Palo Alto, California
Attn: Technical Information
Center

Mr. Henry V. Marmon
CANEL Pump Group
Pratt & Whitney Aircraft Corp.
Middletown, Conn.

Kaman Aircraft Corp.
Bloomfield, Conn.
Attention: Dr. B. Posniak

Aero Res. Laboratory
Bldg. 450
Wright Patterson Air Force Base
Ohio